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(54) **Pressure sensitive adhesive sheet and method of use thereof**

(57) A pressure sensitive adhesive sheet comprising a substrate, an intermediate layer superimposed thereon and a pressure sensitive adhesive layer superimposed on the intermediate layer, characterized in that

the pressure sensitive adhesive layer exhibiting an elastic modulus at 23°C ranging from 5.0×10^4 to 1.0×10^7 Pa, the intermediate layer exhibiting an elastic modulus at 23°C which is not greater than the elastic modulus at 23°C of the pressure sensitive adhesive layer, or

the intermediate layer exhibiting an elastic modulus at 40°C of less than 1.0×10^6 Pa. At the time of working of the back of an adherend having a surface whose unevenness height differences are large, this pressure sensitive adhesive sheet is preferably stuck to the adherend surface to thereby protect it during the working. In particular, when the adherend is to be ground to an extremely small thickness, the pressure sensitive adhesive sheet enables performing the grinding at a uniform thickness without the occurrence of dimples.

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DescriptionFIELD OF THE INVENTION

5 [0001] The present invention relates to a pressure sensitive adhesive sheet. More particularly, the present invention relates to a pressure sensitive adhesive sheet which, at the time of working of the back of an adherend having a surface whose unevenness (irregularity) height differences are large, is preferably stuck to the adherend surface to thereby protect it during the working.

10 BACKGROUND OF THE INVENTION

[0002] In the step of grinding the back of a semiconductor wafer, the surface thereof having electrical circuits formed thereon is protected by a pressure sensitive adhesive sheet. The height differences of customary circuits attributed to electrode elements have ranged from about 5 to 20 μm . For the wafer having these customary circuits formed thereon, the conventional surface protective sheets can fully protect the circuits without the occurrence of circuit break-
15 age or wafer cracking and thus have been satisfactory.

[0003] However, in recent years, the method of mounting IC chips is being diversified. For example, the packaging method in which an IC chip circuit surface is arranged down has been developed. In this packaging method, electrode elements protrude from the circuit surface and the height differences thereof are 30 μm or more, occasionally greater than 100 μm . Protrudent portions formed on the surface of semiconductor wafers like those mentioned above are called bumps.
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[0004] At least two bumps are generally formed per chip. When the number of bumps is large, the bump pitch (distance between bumps) may be hundreds of microns. Depending on bump pitch pattern and chip arrangement, there occur dense portions where the bumps gather and portions where the bump pattern is sparse. In particular, the periph-
25 ery of wafers is likely to become sparse in bump portions because of the absence of chips. With respect to wafers having the pressure sensitive adhesive sheet stuck thereto, the thicknesses thereof at dense bump sites and sparse bump sites conspicuously differ. The grinding of such wafers having conspicuous thickness differences would cause the problem that the thickness differences lead to a difference of ground wafer thickness.

[0005] When the grinding of the back of the wafer furnished with such bumps is carried out while protecting the wafer surface with the conventional surface protective sheet, the wafer back is deeply ground in conformity with the configuration of the bumps to thereby form recesses (dimples) on the back of the wafer with the result that the thickness of the wafer becomes nonuniform. Further, it has been encountered that cracking occurs from dimple portions to result in the breakage of the wafer.
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[0006] A similar problem is encountered with respect to ink provided for the marking of failure circuits (bad mark) after the inspection of the wafer circuits.
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[0007] For the semiconductor wafers having large bumps, measures have been taken, which include, for example, decreasing the hardness of the substrate film of the surface protective sheet or increasing the thickness of the pressure sensitive adhesive sheet. These measures, however, have been unsatisfactory, and the above problems have not yet been resolved.
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OBJECT OF THE INVENTION

[0008] The present invention has been made in view of the above state of the prior art. It is an object of the present invention to provide a pressure sensitive adhesive sheet which, at the time of working of the back of an adherend having a surface whose unevenness height differences are large, is preferably stuck to the adherend surface to thereby protect it during the working. In particular, the object of the present invention is to provide a pressure sensitive adhesive sheet which, when the adherend is to be ground to an extremely small thickness, enables performing the grinding at a uniform thickness without the occurrence of dimples.
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50 SUMMARY OF THE INVENTION

[0009] The first pressure sensitive adhesive sheet of the present invention comprises a substrate, an intermediate layer superimposed thereon and a pressure sensitive adhesive layer superimposed on the intermediate layer,

55 the above pressure sensitive adhesive layer exhibiting an elastic modulus at 23°C ranging from 5.0×10^4 to 1.0×10^7 Pa, the above intermediate layer exhibiting an elastic modulus at 23°C which is not greater than the elastic modulus at 23°C of the pressure sensitive adhesive layer.

[0010] The second pressure sensitive adhesive sheet of the present invention comprises a substrate, an intermediate layer superimposed thereon and a pressure sensitive adhesive layer superimposed on the intermediate layer,

the above intermediate layer exhibiting an elastic modulus at 40°C of less than 1.0×10^6 Pa.

[0011] In the present invention, it is preferred that the substrate exhibit a maximum value of $\tan \delta$ of dynamic viscoelasticity of at least 0.5 at a temperature ranging from -5 to 80°C.

[0012] The substrate preferably has a thickness and Young's modulus whose multiplication product is in the range of 0.5 to 100 kg/cm.

[0013] Moreover, the method of using the pressure sensitive adhesive sheet according to the present invention comprises sticking the pressure sensitive adhesive sheet to a surface of an adherend and working the adherend at its back while protecting the adherend surface by means of the pressure sensitive adhesive sheet.

[0014] Thus, the present invention provides a surface protective pressure sensitive adhesive sheet which desirably follows unevennesses formed at an adherend surface to thereby absorb unevenness in height differences, so that a smooth back grinding of the adherend can be performed without being influenced by the surface unevennesses and, hence, without thickness difference. Further, the present invention provides a method of using a pressure sensitive adhesive sheet, characterized by the use of this surface protective pressure sensitive adhesive sheet.

DETAILED DESCRIPTION OF THE INVENTION

[0015] The present invention will be described in greater detail below. First of all, the first pressure sensitive adhesive sheet according to the present invention will be illustrated.

[0016] The first pressure sensitive adhesive sheet of the present invention comprises a substrate, an intermediate layer and a pressure sensitive adhesive layer arranged in this order.

[0017] The pressure sensitive adhesive layer can be formed from various conventional pressure sensitive adhesives. The elastic modulus at 23°C of the pressure sensitive adhesive layer is in the range of 5.0×10^4 to 1.0×10^7 Pa, preferably 6.0×10^4 to 5.0×10^6 Pa, and still preferably 8.0×10^4 to 1.0×10^6 Pa. When the pressure sensitive adhesive layer is composed of an energy radiation (energy beam) curable pressure sensitive adhesive described later, the elastic modulus referred to is that exhibited by the pressure sensitive adhesive layer prior to the energy radiation irradiation.

[0018] When the elastic modulus at 23°C of the pressure sensitive adhesive layer is lower than 5.0×10^4 Pa, it is likely for the pressure sensitive adhesive to ooze from edges of the pressure sensitive adhesive sheet, or likely for the pressure sensitive adhesive to suffer from a shearing deformation by grinding force because of insufficient cohesive strength, with the result that the difference of ground wafer thickness is increased. Further, if a shear force applies to the pressure sensitive adhesive having got into bump recesses, the danger of remaining of the pressure sensitive adhesive on the wafer surface is high. On the other hand, when the elastic modulus at 23°C of the pressure sensitive adhesive layer is higher than 1.0×10^7 Pa, the pressure sensitive adhesive layer becomes hard and its capability for following bump unevennesses is deteriorated. Consequently, problems such as an increase of the difference of ground wafer thickness and an invasion of cooling water for grinding through gaps between bumps and the pressure sensitive adhesive sheet are likely to occur.

[0019] The pressure sensitive adhesive, although not limited at all, can be selected from among, for example, rubber, acrylic, silicone and polyvinyl ether based pressure sensitive adhesives. Further, use can be made of energy radiation curable, heat foaming or water swellable pressure sensitive adhesives.

[0020] Among the energy radiation curable (energy ray curable, ultraviolet curable, electron beam curable) pressure sensitive adhesives, ultraviolet curable pressure sensitive adhesives are preferred. With respect to the water swellable pressure sensitive adhesives, for example, those disclosed in Japanese Patent Publication Nos. 5(1993)-77284 and 6(1994)-101455 are preferably used.

[0021] The energy radiation curable pressure sensitive adhesive generally contains an acrylic pressure sensitive adhesive and an energy radiation polymerizable compound as main components.

[0022] For example, low-molecular-weight compounds having in the molecule thereof at least two photopolymerizable carbon to carbon double bonds that can be converted into a three-dimensional network structure by light irradiation as disclosed in Japanese Patent Laid-open Publication Nos. 60(1985)-196,956 and 60(1985)-223,139 are widely used as the energy radiation polymerizable compounds to be incorporated in the energy radiation curable pressure sensitive adhesives. Specific examples thereof include trimethylolpropane triacrylate, tetramethylolmethane tetraacrylate, pentaerythritol triacrylate, pentaerythritol tetraacrylate, dipentaerythritol monohydroxypentaacrylate, dipentaerythritol hexaacrylate, 1,4-butylene glycol diacrylate, 1,6-hexanediol diacrylate, polyethylene glycol diacrylate and commercially available oligoester acrylates.

[0023] Furthermore, besides the above acrylate compounds, urethane acrylate oligomers can be used as the energy radiation polymerizable compounds. Urethane acrylate oligomers can be obtained by reacting a polyester or

polyether-type polyol compound with a polyisocyanate compound such as 2,4-tolylene diisocyanate, 2,6-tolylene diisocyanate, 1,3-xylylene diisocyanate, 1,4-xylylene diisocyanate or diphenylmethane-4,4'-diisocyanate to thereby obtain an isocyanate terminated urethane prepolymer and by reacting the obtained isocyanate terminated urethane prepolymer with a hydroxyl group containing acrylate or methacrylate, such as 2-hydroxyethyl acrylate, 2-hydroxyethyl methacrylate, 2-hydroxypropyl acrylate, 2-hydroxypropyl methacrylate, polyethylene glycol acrylate or polyethylene glycol methacrylate.

[0024] With respect to the blending ratio of energy radiation polymerizable compound to acrylic pressure sensitive adhesive in the energy radiation curable pressure sensitive adhesive, it is preferred that 50 to 200 parts by weight, especially 50 to 150 parts by weight, and still especially 70 to 120 parts by weight, of the energy radiation polymerizable compound be used per 100 parts by weight of the acrylic pressure sensitive adhesive. In this instance, the initial adhesive strength of the obtained pressure sensitive adhesive sheet is large, and the adhesive strength is sharply decreased upon irradiation of the pressure sensitive adhesive layer with energy radiation. Accordingly, the peeling at the interface of the wafer and the energy radiation curable pressure sensitive adhesive layer to be performed after the completion of wafer back grinding is facilitated.

[0025] The energy radiation curable pressure sensitive adhesive may be composed of an energy radiation curable copolymer having an energy radiation polymerizable group as a side chain. This energy radiation curable copolymer simultaneously exhibits satisfactory adherence and energy radiation curability properties. Details of the energy radiation curable copolymer having an energy radiation polymerizable group as a side chain are described in, for example, Japanese Patent Laid-open Publication Nos. 5(1993)-32,946 and 8(1996)-27,239.

[0026] The time spent for photopolymerization and the photoirradiation dose can be reduced by mixing a photopolymerization initiator into the energy radiation curable pressure sensitive adhesive.

[0027] This photopolymerization initiator can be a photoinitiator such as a benzoin compound, an acetophenone compound, an acylphosphine oxide compound, a titanocene compound, a thioxanthone compound or a peroxide compound, or a photosensitizer such as an amine or a quinone. Specific examples thereof include 1-hydroxycyclohexyl phenyl ketone, benzoin, benzoin methyl ether, benzoin ethyl ether, benzoin isopropyl ether, benzyl diphenyl sulfide, tetramethylthiuram monosulfide, azobisisobutyronitrile, dibenzyl, diacetyl and β -chloroanthraquinone.

[0028] The photopolymerization initiator is preferably added in an amount of 0.05 to 15 parts by weight, still preferably 0.1 to 10 parts by weight, and optimally 0.5 to 5 parts by weight, to 100 parts by weight of the resin total.

[0029] The above acrylic energy radiation curable pressure sensitive adhesive possesses satisfactory adhesive strength to the wafer before irradiation with energy radiation, and the adhesive strength is extremely decreased upon irradiation with energy radiation. That is, the acrylic energy radiation curable pressure sensitive adhesive enables the bonding of the wafer with the pressure sensitive adhesive sheet with a satisfactory adhesive strength to thereby attain a surface protection before irradiation with energy radiation, but, after irradiation with energy radiation, enables easy stripping of the sheet from the ground wafer.

[0030] The elastic modulus at 23°C of the intermediate layer is not greater than the elastic modulus at 23°C of the pressure sensitive adhesive layer. Preferably, the elastic modulus at 23°C of the intermediate layer is in the range of 1 to 100%, especially 10 to 90%, and still especially 30 to 80%, of the elastic modulus at 23°C of the pressure sensitive adhesive layer.

[0031] When the elastic moduli of the pressure sensitive adhesive layer and the intermediate layer at 23°C satisfy the above relationship, not only can the sticking of the pressure sensitive adhesive sheet be effected in such a manner that the pressure sensitive adhesive sheet satisfactorily follows bump unevennesses but also the shear force to the pressure sensitive adhesive layer is dispersed to thereby prevent the pressure sensitive adhesive remaining at the time of stripping. Furthermore, the sticking can be effected so that there is no thickness difference between dense bump portions and sparse bump portions on the wafer surface.

[0032] The material composing the intermediate layer is not particularly limited as long as the above properties can be realized. For example, it can be selected from among various pressure sensitive adhesive compositions such as those based on acrylics, rubbers and silicones, and thermoplastic elastomers and ultraviolet curable resins that can be employed in the preparation of a substrate as described later.

[0033] The intermediate layer is preferably composed of a material which exhibits a maximum value of $\tan \delta$ of dynamic viscoelasticity (hereinafter referred to simply as " $\tan \delta$ value") of at least 0.3, especially 0.4 to 2.0, and still especially 0.5 to 1.2, at a temperature ranging from 0 to 60°C. The terminology " $\tan \delta$ " used herein means the loss tangent which defines the ratio of loss of elastic modulus to storage elastic modulus. For example, it is measured by the use of a dynamic viscoelasticity measuring instrument on the basis of response to a stress such as tension or torsion applied to an object.

[0034] The upper surface, i.e., side on which the pressure sensitive adhesive layer is formed, of the intermediate layer may be provided with corona treatment or furnished with another layer such as a primer in order to increase the adherence to the pressure sensitive adhesive.

[0035] Although various films commonly used in pressure sensitive adhesive sheets can be employed without any

particular limitation as the substrate, preferred use is made of films which exhibit a dynamic viscoelasticity " $\tan \delta$ value" of at least 0.5, especially 0.5 to 2.0, and still especially 0.7 to 1.8, at a temperature ranging from -5 to 80°C.

[0036] It is preferred that the multiplication product of the thickness and Young's modulus of the substrate be in the range of 0.5 to 100 kg/cm, especially 1.0 to 50 kg/cm, and still especially 2.0 to 40 kg/cm.

[0037] When the multiplication product of the thickness and Young's modulus of the substrate falls within the above range, the mechanical aptitude, for example, sticking aptitude of the pressure sensitive adhesive sheet is enhanced to thereby increase the work efficiency.

[0038] The substrate is preferably composed of a resin film. The substrate may be prepared by either molding a curable resin into a film and curing the film or by molding a thermoplastic resin.

[0039] For example, an energy radiation curable resin or a thermosetting resin is used as the curable resin. Preferred use is made of an energy radiation curable resin.

[0040] The energy radiation curable resin is preferably selected from among, for example, resin compositions whose principal component is a photopolymerizable urethane acrylate oligomer and polyene/thiol resins.

[0041] This urethane acrylate oligomer can be obtained by reacting a polyester or polyether type polyol compound with a polyisocyanate compound such as 2,4-tolylene diisocyanate, 2,6-tolylene diisocyanate, 1,3-xylylene diisocyanate, 1,4-xylylene diisocyanate or diphenylmethane-4,4'-diisocyanate to thereby obtain an isocyanate-terminal urethane prepolymer and by reacting this isocyanate-terminal urethane prepolymer with a hydroxyl group containing acrylate or methacrylate such as 2-hydroxyethyl acrylate, 2-hydroxyethyl methacrylate, 2-hydroxypropyl acrylate, 2-hydroxypropyl methacrylate, polyethylene glycol acrylate or polyethylene glycol methacrylate. This urethane acrylate oligomer has a photopolymerizable double bond in its molecule and undergoes polymerization and curing when irradiated with light to thereby form a film.

[0042] The molecular weight of urethane acrylate oligomers preferably used in the present invention is in the range of 1000 to 50,000, especially 2000 to 30,000. These urethane acrylate oligomers can be used either individually or in combination.

[0043] It is often difficult to obtain a film only from the above urethane acrylate oligomers. Thus, films are generally obtained by diluting the urethane acrylate oligomer with a photopolymerizable monomer, conducting a film formation and curing the film. The photopolymerizable monomer has a photopolymerizable double bond in its molecule, and, in the present invention, preferred use is made of an acrylic ester compound having a relatively bulky group.

[0044] The photopolymerizable monomer employed for diluting the urethane acrylate oligomer is, for example, selected from among:

alicyclic compounds such as isobornyl (meth)acrylate, dicyclopentenyl (meth)acrylate, dicyclopentanyl (meth)acrylate, dicyclopentenyl (meth)acrylate, cyclohexyl (meth)acrylate and adamantane (meth)acrylate;
aromatic compounds such as phenylhydroxypropyl acrylate, benzyl acrylate and phenol ethylene oxide modified acrylate; and
heterocyclic compounds such as tetrahydrofurfuryl (meth)acrylate, morpholinyl acrylate, N-vinylpyrrolidone and N-vinylcaprolactam. According to necessity, use may be made of polyfunctional (meth)acrylates.

[0045] The above photopolymerizable monomer is preferably added in an amount of 5 to 900 parts by weight, still preferably 10 to 500 parts by weight, and optimally 30 to 200 parts by weight, to 100 parts by weight of the urethane acrylate oligomer.

[0046] On the other hand, the photopolymerizable polyene/thiol resin for use in the production of the substrate comprises of a polyene compound having no acryloyl group and a polythiol compound. Specifically, the polyene compound is selected from among, for example, diacrolein pentaerythritol, trimethylolpropane diallyl ether adduct of tolylene diisocyanate and unsaturated allylurethane oligomer. Mercaptoacetic acid or mercaptopropionic acid ester of pentaerythritol can preferably be used as the polythiol compound. Furthermore, use can be made of commercially available polyene polythiol oligomers. The molecular weight of the polyene/thiol resin for use in the present invention is preferably in the range of 3000 to 50,000, still preferably 5000 to 30,000.

[0047] In the forming of the substrate from the energy radiation curable resin, the time spent for photopolymerization and the photoirradiation dose can be reduced by mixing a photopolymerization initiator into the resin.

[0048] This photopolymerization initiator can be as aforementioned and is preferably added in an amount of 0.05 to 15 parts by weight, still preferably 0.1 to 10 parts by weight, and optimally 0.5 to 5 parts by weight, to 100 parts by weight of the resin total.

[0049] In the production of the above curable resin, oligomer and monomer can be selected from among various combinations so that the above properties can be realized.

[0050] The thermoplastic resin for preparing the substrate can be selected from among, for example, polyolefin resins such as polyethylene, polypropylene, polybutene, polybutadiene and polymethylpentene; and nonhydrogenated or hydrogenated styrene-vinylisoprene block copolymer. Of these, nonhydrogenated or hydrogenated styrene-vinyliso-

prene block copolymer is preferred.

[0051] The styrene-vinylisoprene block copolymer is generally a high vinyl bond SIS (styrene-isoprene-styrene block copolymer). Both the nonhydrogenated and hydrogenated styrene-vinylisoprene block copolymers per se exhibit a high peak of $\tan\delta$ at about room temperature.

[0052] Additives capable of enhancing the $\tan\delta$ value are preferably added to the above resin. Examples of the additives capable of enhancing the $\tan\delta$ value include inorganic fillers such as calcium carbonate, silica and mica and metal fillers such as iron and lead. Especially, the addition of metal fillers having a high specific gravity is effective.

[0053] Further, the substrate may contain other additives, for example, colorants such as pigments and dyes in addition to the above components.

[0054] With respect to the film forming method, for example, the substrate can be produced by first casting a liquid resin (for example, preure resin or resin solution) onto a processing sheet in the form of a thin coating and subsequently conducting given steps for film formation. In this method, the stress loaded on the resin during the film formation is small, so that the occurrence of fish eye is reduced. Moreover, the uniformity of the film thickness is high and the thickness precision generally falls within 2%.

[0055] Another preferred method of forming a film comprises calendering or extrusion forming with the use of T die or inflation.

[0056] The pressure sensitive adhesive sheet of the present invention is produced by forming the pressure sensitive adhesive layer on the intermediate layer superimposed on the above substrate. When the pressure sensitive adhesive layer is composed of an ultraviolet curable pressure sensitive adhesive, the substrate and the intermediate layer must be transparent substrate.

[0057] In the pressure sensitive adhesive sheet of the present invention, the thickness of the substrate is preferably in the range of 30 to 1000 μm , still preferably 50 to 800 μm , and optimally 80 to 500 μm .

[0058] The thickness of the intermediate layer is preferably in the range of 5 to 100 μm , still preferably 10 to 80 μm , and optimally 20 to 60 μm . Further, the thickness of the pressure sensitive adhesive layer, although depending on the type of material composing the same, is generally in the range of about 5 to 100 μm , preferably about 10 to 80 μm , and about optimally 20 to 60 μm .

[0059] The total thickness of the intermediate layer and the pressure sensitive adhesive layer is appropriately determined taking into account the bump height, bump configuration, bump interval pitch, etc. on an adherend to which the pressure sensitive adhesive sheet is stuck. It is generally preferred that the total thickness of the intermediate layer and the pressure sensitive adhesive layer be determined so as to be at least 50%, especially 60 to 100%, of the bump height. When the total thickness of the intermediate layer and the pressure sensitive adhesive layer is so determined, the pressure sensitive adhesive sheet follows circuit surface unevennesses to thereby enable canceling the unevenness height differences.

[0060] The pressure sensitive adhesive sheet of the present invention can be obtained by applying a resin for constituting an intermediate layer onto a substrate; drying or curing the resin by appropriate means to thereby form an intermediate layer; coating the intermediate layer with the above pressure sensitive adhesive in appropriate thickness according to the customary technique employing a roll coater, a knife coater, a gravure coater, a die coater, a reverse coater or the like; and drying the pressure sensitive adhesive to thereby form a pressure sensitive adhesive layer on the intermediate layer. When considered necessary, a release liner is applied onto the pressure sensitive adhesive layer.

[0061] Next, the second pressure sensitive adhesive sheet according to the present invention will be illustrated.

[0062] The second pressure sensitive adhesive sheet of the present invention comprises a substrate, an intermediate layer and a pressure sensitive adhesive layer arranged in this order. Though various types of substrates and pressure sensitive adhesives can be used in the second pressure sensitive adhesive sheet, preferably used are those explained for the first pressure sensitive adhesive sheet.

[0063] The intermediate layer of the second pressure sensitive adhesive sheet exhibits an elastic modulus at 40°C of less than 1.0×10^6 Pa, preferably 5.0×10^3 to 5.0×10^5 Pa, more preferably 1.0×10^4 to 1.0×10^5 Pa.

[0064] When grinding the back of the semiconductor wafer, the temperature of the pressure sensitive adhesive sheet would be about 40°C by grinding heat. Therefore, the elastic modulus of the intermediate layer at this temperature is significant. That is, when the elastic modulus of the intermediate layer at 40°C is within the above range, the pressure sensitive adhesive sheet can precisely follow the unevenness of an adherend surface to thereby absorb the unevenness in height differences at the time of grinding the back of the adherend, to thereby accomplish a smooth back grinding free of thickness differences, without being affected by the unevenness of the adherend surface, regardless of types of the substrate and pressure sensitive adhesive.

[0065] Preferred embodiments such as thickness etc. of substrate, intermediate layer and pressure sensitive layer of the second pressure sensitive adhesive sheet are the same as those described in the first pressure sensitive adhesive sheet, and the production thereof can be performed in the same manner as described in the first pressure sensitive adhesive sheet.

[0066] The first and second pressure sensitive adhesive sheets of the present invention are used to protect the sur-

face of various items and to effect temporary fixing thereof at the time of precision working. In particular, the pressure sensitive adhesive sheet is suitably used as one for protecting the circuit surface during the grinding of the back of semiconductor wafers. The pressure sensitive adhesive sheet of the present invention has the above specified structure and hence effectively absorbs the unevennesses of the circuit surface. Therefore, the pressure sensitive adhesive sheet of the present invention can not only be stuck with satisfactory adherence to wafers having large surface height differences because of bumps and the like but also mitigate the influence of the unevennesses of the wafer surface to the back grinding to thereby enable the accomplishment of an extremely smooth grinding as well as prevention of the wafer breakage. Moreover, when the pressure sensitive adhesive layer is composed of, for example, an ultraviolet curable pressure sensitive adhesive, the adhesive strength thereof can be easily reduced by ultraviolet irradiation, so that, after the completion of required working, the pressure sensitive adhesive layer can be easily stripped off by irradiating the pressure sensitive adhesive layer with ultraviolet rays.

EFFECT OF THE INVENTION

[0067] This invention provides a surface protective pressure sensitive adhesive sheet which can precisely follow the unevenness of an adherend surface to thereby absorb the uneven height differences and which, at the time of grinding of the back of the adherend, enables a smooth back grinding free of thickness difference to be accomplished without being affected by the unevenness of the adherend surface.

EXAMPLE

[0068] The present invention will further be illustrated below with reference to the following Examples which in no way limit the scope of the invention.

[0069] In the following Examples and Comparative Examples, the "back grinding aptitude test" was carried out in the following manner.

Back grinding aptitude test

[0070] The following printed dotted bad marks as bumps were provided on a 6-inch mirror wafer. Each pressure sensitive adhesive sheet was stuck to the wafer surface provided with the bad mark, and the opposite surface of the wafer was ground. The wafer configuration, grinding conditions and evaluation method were as follows:

(1) Wafer configuration

[0071]

wafer diameter: 6 inches (15.24 cm),
thickness of wafer (thickness of portion where no dot printing was made): 650 to 700 μm ,
dot diameter: 500 to 600 μm ,
dot height: 105 μm , and
dot pitch: 2.0 mm interval (no printing was made up to 20 mm from the wafer circumference);

(2) Back grinding conditions

[0072]

finish thickness: 200 μm , and
grinding apparatus: grinder DFG 840 manufactured by Disco Corporation; and

(3) Evaluation method

(3-1) Dimples

[0073] ground wafer back was observed. When there was no crack or dimple, the wafer was evaluated as "excellent". When dimples were observed but the maximum depth thereof was less than 2 μm , the wafer was evaluated as "good". On the other hand, when dimples were observed and the maximum depth thereof was 2 μm or more, the wafer was evaluated as "failure".

(3-2) Difference of wafer thickness

[0074] After the completion of back grinding, the pressure sensitive adhesive sheet was stripped from the wafer. The thickness was measured at 30 points, including those lying within 20 mm from the wafer circumference, of the wafer. The difference means the wafer thickness maximum minus the wafer thickness minimum.

[0075] The measuring was performed by the use of Dial Thickness Gauge (manufactured by Ozaki Mfg. Co., Ltd.).

tan δ

[0076] The tan δ was measured by a dynamic viscoelasticity measuring instrument at a 110 Hz tensile stress. Specifically, each substrate was sampled into a given size, and the tan δ was measured at a frequency of 110 Hz and at temperatures ranging from -40 to 150°C with the use of Rheovibron DDV-II-EP manufactured by Orientec Corporation. With respect to the substrate, the maximum value of measured tan δ at temperatures ranging from -5 to 80°C was defined as "tan δ value". With respect to the intermediate layer, the maximum value of measured tan δ at temperatures ranging from 0 to 60°C was defined as "tan δ value".

Young's modulus

[0077] The Young's modulus was measured at a test speed of 200 mm/min in accordance with Japanese Industrial Standard (JIS) K7127.

Elastic modulus

[0078] The elastic modulus G' of each of the pressure sensitive adhesive and the intermediate layer was measured by the torsional shear method, wherein,

specimen: cylinder of 8 mm diameter x 3 mm height,
instrument: Dynamic Analyzer RDA II (manufactured by Reometric), and
frequency: 1 Hz.

Example 1

[0079] 50 parts by weight of urethane acrylate oligomer having a weight average molecular weight of 5000 (produced by Arakawa Chemical Industry Co., Ltd.), 25 parts by weight of isobornyl acrylate, 25 parts by weight of phenyl-hydroxypropyl acrylate, 2.0 parts by weight of 1-hydroxycyclohexyl phenyl ketone as a photopolymerization initiator (Irgacure 184 produced by Ciba-Geigy) and 0.2 part by weight of phthalocyanine pigment were blended together, thereby obtaining an energy radiation curable resin composition.

[0080] PET film (produced by Toray Industries, Inc., thickness: 38 μ m) as a casting processing sheet was coated with the thus obtained resin composition at a thickness of 110 μ m according to the fountain die technique, thereby forming a resin composition layer. Immediately after the coating, the resin composition layer was laminated with the same PET film and thereafter irradiated with ultraviolet rays emitted from a high pressure mercury lamp (160 W/cm, height 10 cm) at a dose of 250 mJ/cm² so that the resin composition layer was crosslinked and cured. Thus, a substrate film of 110 μ m thickness was obtained. The tan δ and Young's modulus of this substrate film were measured by the above methods. The results are given in Table 1.

[0081] A composition was prepared by blending together 60 parts by weight of urethane acrylate (produced by Toagosei Chemical Industry Co., Ltd.), 20 parts by weight of phenol ethylene oxide modified acrylate (trade name: M-101, produced by Toagosei Chemical Industry Co., Ltd.), 10 parts by weight of isobornyl acrylate and 2.0 parts by weight of photopolymerization initiator (Irgacure 184 produced by Ciba-Geigy), and cast on one side of the above substrate film according to the fountain die technique. Thus, an intermediate layer of 40 μ m thickness was formed. The tan δ and Young's modulus of this intermediate layer were measured by the above methods. The results are given in Table 1.

[0082] A pressure sensitive adhesive composition was prepared by blending together 100 parts by weight of acrylic pressure sensitive adhesive (copolymer of n-butyl acrylate and acrylic acid), 120 parts by weight of urethane acrylate oligomer whose molecular weight was 8000, 10 parts by weight of curing agent (diisocyanate compound) and 5 parts by weight of photopolymerization initiator (benzophenone compound), applied onto the intermediate layer, and dried so that a pressure sensitive adhesive layer of 20 μ m thickness was formed. Thus, a pressure sensitive adhesive sheet was obtained.

[0083] The back grinding aptitude test of the obtained pressure sensitive adhesive sheet was conducted. The results are given in Table 1.

Example 2

[0084] The same procedure as in Example 1 was repeated except that a 20 μm thick intermediate layer was formed from a composition comprising 100 parts by weight of a copolymer of n-butyl acrylate and acrylic acid and 5 parts by weight of curing agent (diisocyanate compound) and that the thickness of the pressure sensitive adhesive layer was 40 μm . The results are given in Table 1.

Example 3

[0085] The same procedure as in Example 1 was repeated except that the substrate was formed by employing 50 parts by weight of isobornyl acrylate without using the phenylhydroxypropyl acrylate, a 20 μm thick intermediate layer was formed from a composition comprising a mixture of 100 parts by weight of a copolymer of 2-ethylhexyl acrylate, vinyl acetate and acrylic acid and 5 parts by weight of epoxy curing agent (Tetrad C) and a 40 μm pressure sensitive adhesive layer was formed from a composition comprising the acrylic pressure sensitive adhesive of Example 1 and 5 parts by weight of curing agent (diisocyanate compound). The results are given in Table 1.

Example 4

[0086] The same procedure as in Example 2 was repeated except that 110 μm thick low-density polyethylene film (trade name: Sumikathene L705) was used as a substrate film. The results are given in Table 1.

Comparative Example 1

[0087] The same procedure as in Example 1 was repeated except that an intermediate layer was not formed. The results are given in Table 1.

Comparative Example 2

[0088] The same procedure as in Example 1 was repeated except that a 40 μm thick intermediate layer was formed by applying a composition comprising a mixture of 5 parts by weight of isocyanate curing agent and 100 parts by weight of an acrylic copolymer of 90 parts by weight of vinyl acetate, 8 parts by weight of methyl methacrylate and 2 parts by weight of acrylic acid, followed by drying. The results are given in Table 1.

Comparative Example 3

[0089] The same procedure as in Example 4 was repeated except that an intermediate layer was not formed and that the thickness of the pressure sensitive adhesive layer was 20 μm . The results are given in Table 1.

Comparative Example 4

[0090] The same procedure as in Example 1 was repeated except that a 120 μm thick ethylene/vinyl acetate copolymer film (vinyl acetate content: 12%) was used as a substrate film, an intermediate layer was not formed and a 10 μm thick pressure sensitive adhesive layer was formed from the same pressure sensitive adhesive as used in Example 1. The results are given in Table 1.

Comparative Example 5

[0091] The same procedure as in Example 1 was repeated except that a 100 μm thick polyethylene terephthalate film was used as a substrate film, an intermediate layer was not formed and a 10 μm thick pressure sensitive adhesive layer was formed from the same pressure sensitive adhesive as used in Example 1. The results are given in Table 1.

Table 1

	Substrate			Intermediate layer			
	tan δ	thick- ness (μm)	thickness x Young's modulus (kg/cm)	tan δ	thick- ness (μm)	elastic modulus (Pa) 23°C	elastic modulus (Pa) 40°C
Example 1	1.20	110	22.0	1.20	40	5.5x10 ⁴	1.8x10 ⁴
2	1.20	110	22.0	1.50	20	1.0x10 ⁵	3.2x10 ⁵
3	0.75	110	9.0	0.45	20	9.0x10 ⁴	5.0x10 ⁴
4	0.19	110	14.3	1.50	20	1.0x10 ⁵	3.2x10 ⁵
Comp.Ex.1	1.20	110	22.0				
2	1.20	110	22.0	0.5	40	3.0x10 ⁶	1.7x10 ⁶
3	0.19	110	14.3				
4	0.17	120	6.6				
5	0.03	100	350.0				

Table 1 (continued)

	Pressure sensitive adhesive			Back polishing aptitude	difference of wafer thickness (μm)
	thick-ness (μm)	elastic modulus (Pa) 23°C	elastic modulus (Pa) 40°C	dimple	
Example 1	20	1.5×10^5	5.8×10^4	excellent	3.2
2	40	1.5×10^5	5.8×10^4	excellent	4.8
3	40	1.0×10^5	4.1×10^4	excellent	6.0
4	40	1.5×10^5	5.8×10^4	good	6.8
Comp. Ex. 1	20	1.5×10^5		excellent	59
2	20	1.5×10^5	5.8×10^4	excellent	37
3	20	1.5×10^5		failure	72
4	10	1.5×10^5		failure	66
5	10	1.5×10^5		failure	73

Claims

1. A pressure sensitive adhesive sheet comprising a substrate, an intermediate layer superimposed thereon and a pressure sensitive adhesive layer superimposed on the intermediate layer,
said pressure sensitive adhesive layer exhibiting an elastic modulus at 23°C ranging from 5.0×10^4 to 1.0×10^7 Pa, said intermediate layer exhibiting an elastic modulus at 23°C which is not greater than the elastic modulus at 23°C of the pressure sensitive adhesive layer.
2. The pressure sensitive adhesive sheet as claimed in claim 1, wherein the substrate exhibits a maximum value of $\tan \delta$ of dynamic viscoelasticity of at least 0.5 at a temperature ranging from -5 to 80°C.
3. The pressure sensitive adhesive sheet as claimed in claim 1 or claim 2, wherein the substrate has a thickness and Young's modulus whose multiplication product is in the range of 0.5 to 100 kg/cm.
4. A method of using the pressure sensitive adhesive sheet of any of claims 1 to 3, comprising sticking the pressure sensitive adhesive sheet to a surface of an adherend and working the adherend at its back while protecting the adherend surface by means of the pressure sensitive adhesive sheet.
5. A pressure sensitive adhesive sheet comprising a substrate, an intermediate layer superimposed thereon and a pressure sensitive adhesive layer superimposed on the intermediate layer,

said intermediate layer exhibiting an elastic modulus at 40°C of less than 1.0×10^6 Pa.

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6. The pressure sensitive adhesive sheet as claimed in claim 5, wherein the substrate exhibits a maximum value of $\tan \delta$ of dynamic viscoelasticity of at least 0.5 at a temperature ranging from -5 to 80°C.
7. The pressure sensitive adhesive sheet as claimed in claim 5 or claim 6, wherein the substrate has a thickness and Young's modulus whose multiplication product is in the range of 0.5 to 100 kg/cm.
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8. A method of using the pressure sensitive adhesive sheet of any of claims 5 to 7, comprising sticking the pressure sensitive adhesive sheet to a surface of an adherend and working the adherend at its back while protecting the adherend surface by means of the pressure sensitive adhesive sheet.
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